Tracking Impacts and Future Scenarios of Land Cover and Climate Change on GHG Emissions for the Western United States
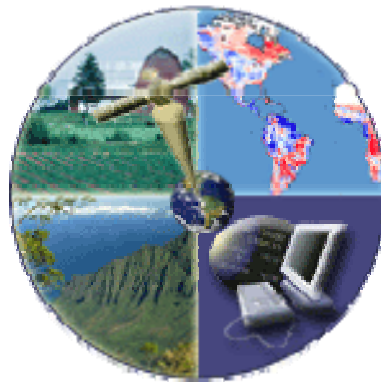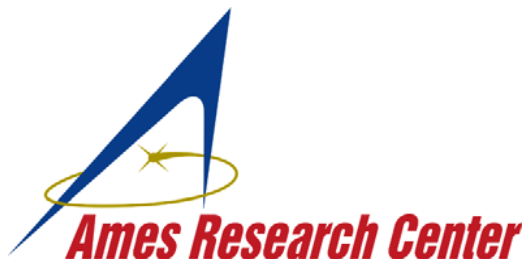
(Supported by Grants from NASA and USDA)

CHRISTOPHER POTTER and **MATTHEW FLADELAND**,
NASA Ames Research Center

STEVEN KLOOSTER, **VANESSA GENOVESE**,
PEGGY GROSS, and **SETH HIATT**, California State University

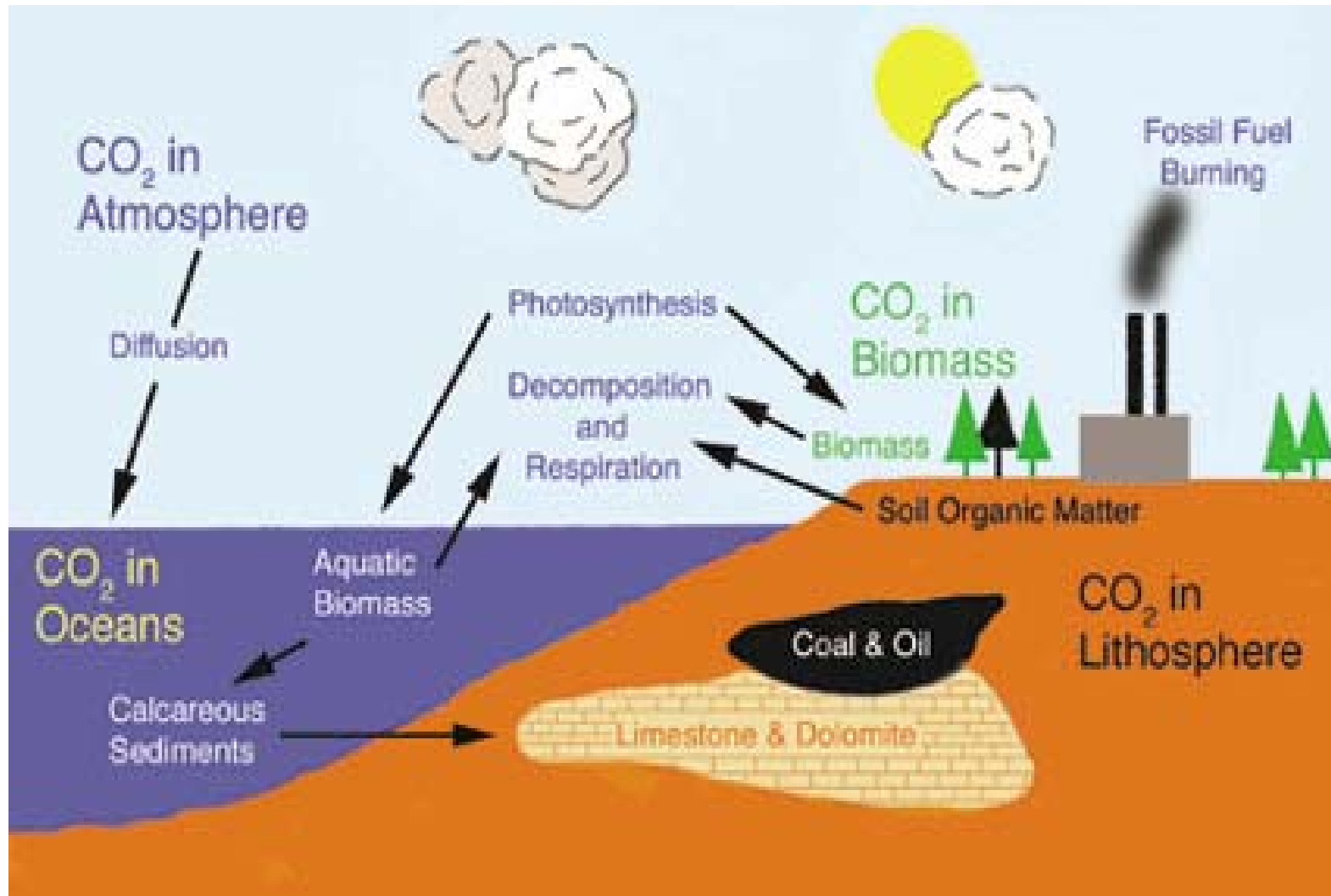Web Site from more information and data queries:
http://geo.arc.nasa.gov/sge/casa/

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CASA CQUEST

CSU Monterey Bay

Tracking the Carbon Cycle and CO_2

"Baseline" Carbon Pools in Terrestrial Ecosystems

| Live Leaf | Standing Wood | Dead Wood | Surface Soil |

"Baselines" comprise the reference case against which a change in GHG emission or removal is measured.

Green plants remove (sequester) carbon from the atmosphere through photosynthesis, extracting carbon dioxide from the air, and using the carbon to make biomass in the form of roots, stems, and foliage. -- Source: Voluntary Reporting of Greenhouse Gases, 2002, Report number DOE/EIA-0608.

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CASA-CQUEST Application:
A Decision Support Tool for US Carbon Management

Supported by NASA Program for Applied Sciences
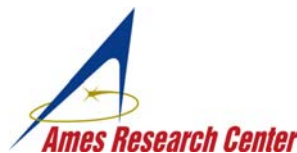http://geo.arc.nasa.gov/website/cquestwebsite/
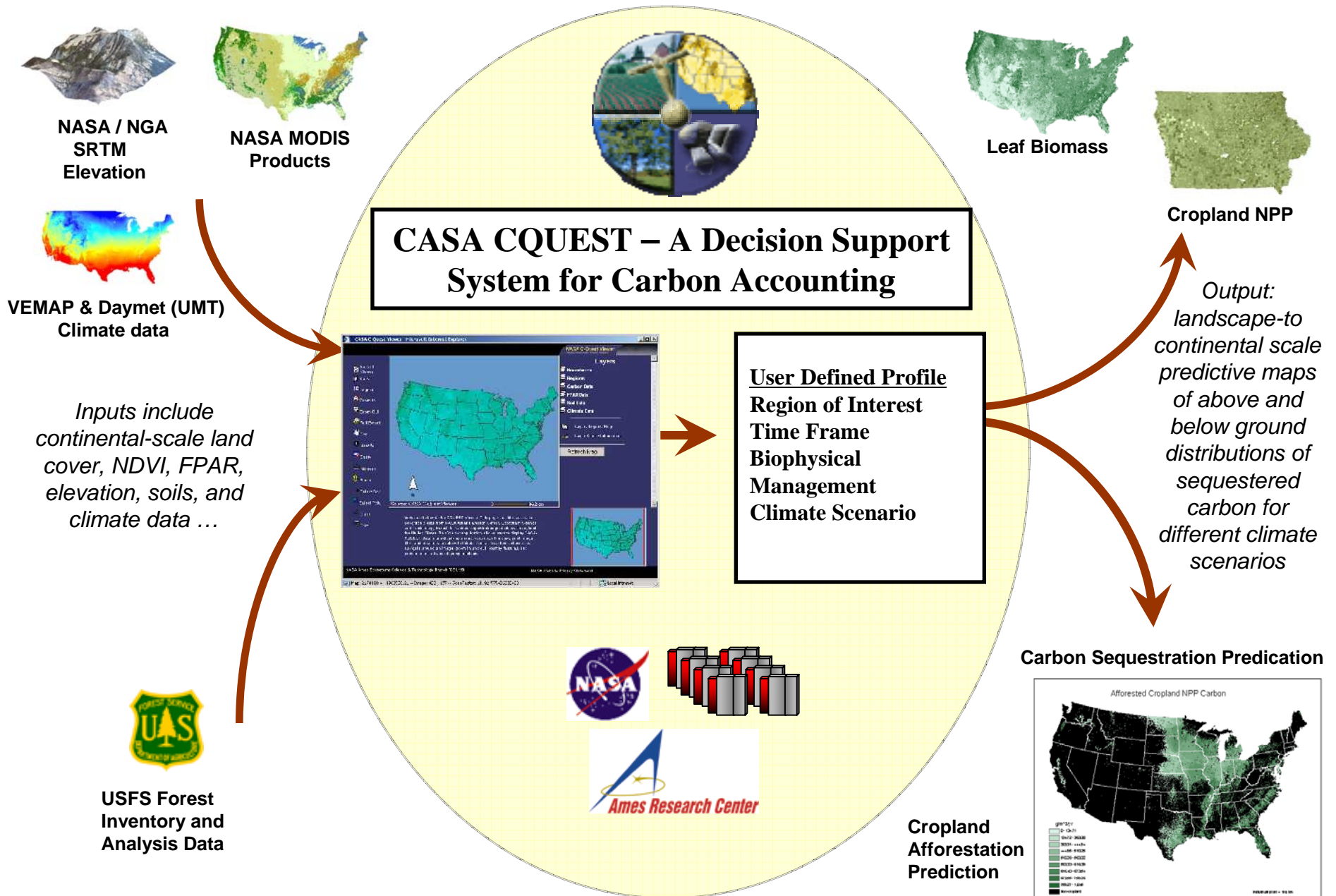
Project Objectives:

1.   **Evaluate major forest and agricultural sinks of atmospheric CO_2 in the U. S. using NASA satellite data and ecosystem modeling.**

2.   **Support the U. S. Government interagency program for registration of voluntary GHG emissions reductions (carbon dioxide, methane, nitrous oxide).**

3.   **Develop an internet-based Decision Support Tools (DST) for carbon management in U. S. ecosystems for users nationwide.**

Investigators:
   Christopher Potter and Matthew Fladeland (NASA ARC)
   Steven Klooster, Vanessa Genovese, Seth Hiatt, and Peggy Gross (CSUMB)

NASA / NGA SRTM Elevation

NASA MODIS Products

VEMAP & Daymet (UMT) Climate data

Inputs include continental-scale land cover, NDVI, FPAR, elevation, soils, and climate data …

USFS Forest Inventory and Analysis Data

Multi-scale Validation Information

CASA CQUEST – A Decision Support System for Carbon Accounting

User Defined Profile
Region of Interest
Time Frame
Biophysical
Management
Climate Scenario

NASA

Ames Research Center

Leaf Biomass

Cropland NPP

Output: landscape-to continental scale predictive maps of above and below ground distributions of sequestered carbon for different climate scenarios

Carbon Sequestration Predication
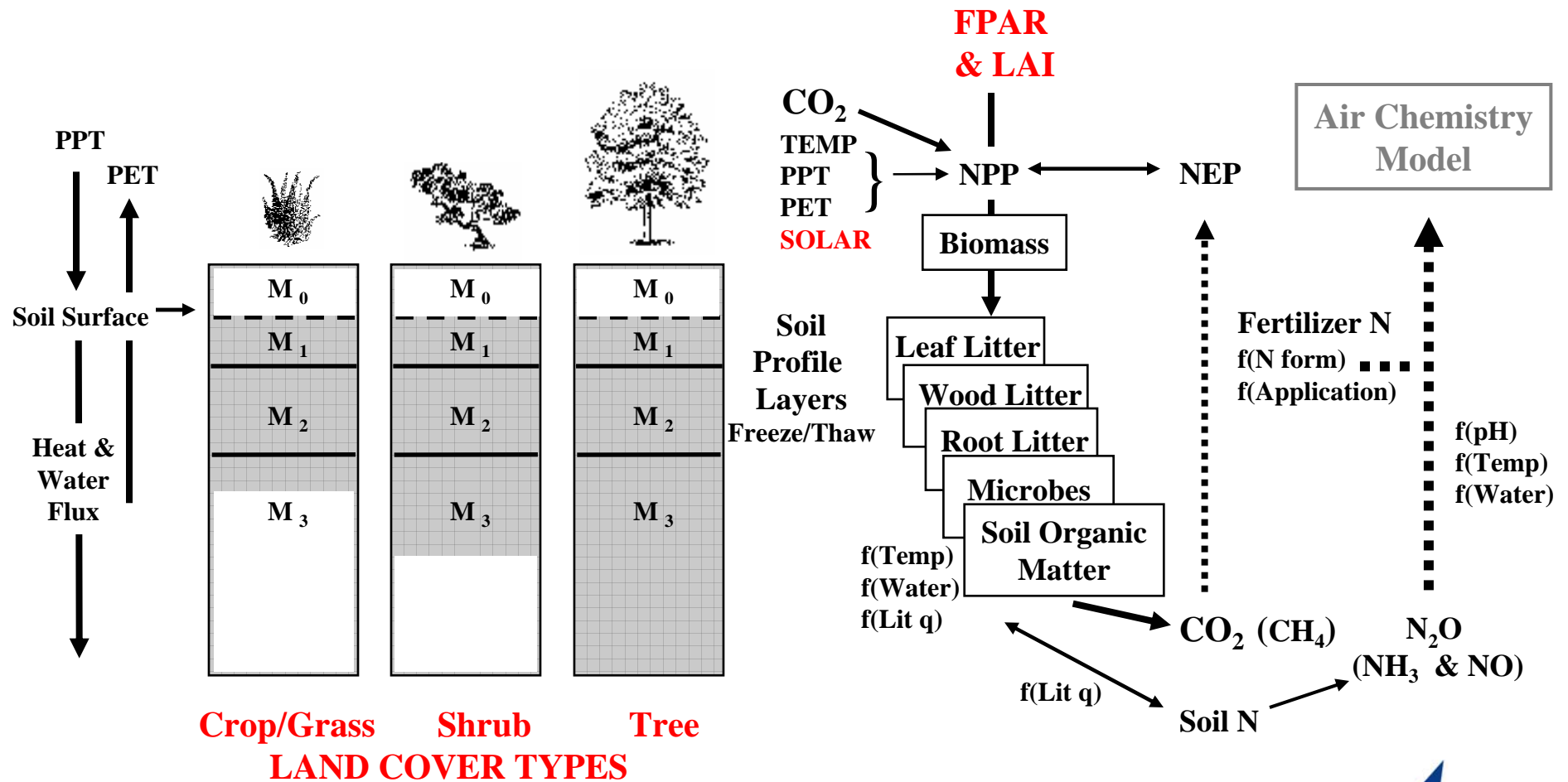
Cropland Afforestation Prediction

NASA-CASA Simulation Model

EOS Satellite Product Inputs

(a) Daily Soil Moisture Balance and Irrigation of Cultivated Land
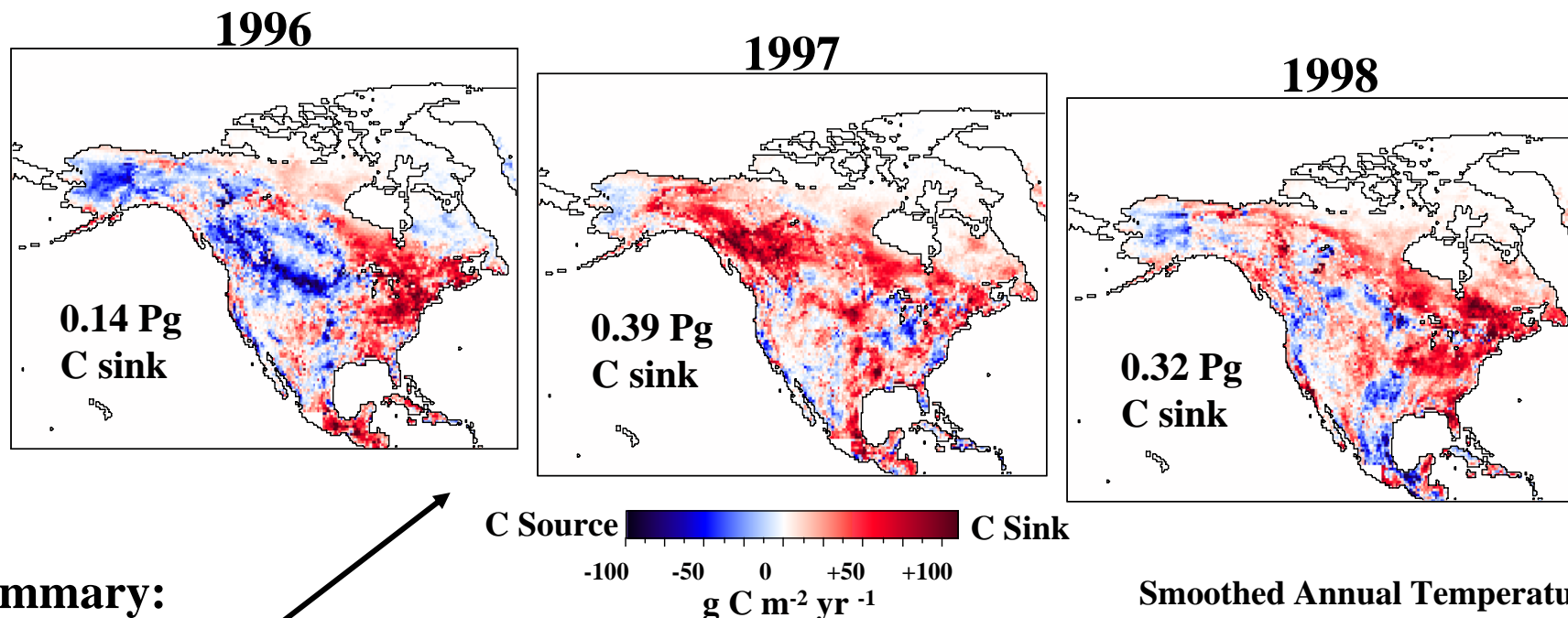
(b) Plant Production and Nutrient Mineralization

(c) Fertilizer Application and Trace Gas Emissions

FPAR & LAI

CO_2

TEMP
PPT
PET
SOLAR

PPT

PET

Soil Surface

Heat & Water Flux

M_0 M_0 M_0

M_1 M_1 M_1

M_2 M_2 M_2

M_3 M_3 M_3

Crop/Grass   Shrub   Tree
LAND COVER TYPES

Soil Profile Layers Freeze/Thaw

NPP ⟷ NEP

Air Chemistry Model

Biomass

Leaf Litter
Wood Litter
Root Litter
Microbes
Soil Organic Matter

f(Temp)
f(Water)
f(Lit q)

f(Lit q)

Soil N

CO_2 (CH_4)

N_2O
$(NH_3$ & NO$)$

Fertilizer N
f(N form)
f(Application)

f(pH)
f(Temp)
f(Water)

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Prediction of the North American Carbon Sink

Fall AGU '01 B52B-03 "The North America Carbon Sink from 1982-1998 Estimated using MODIS Algorithm Products"
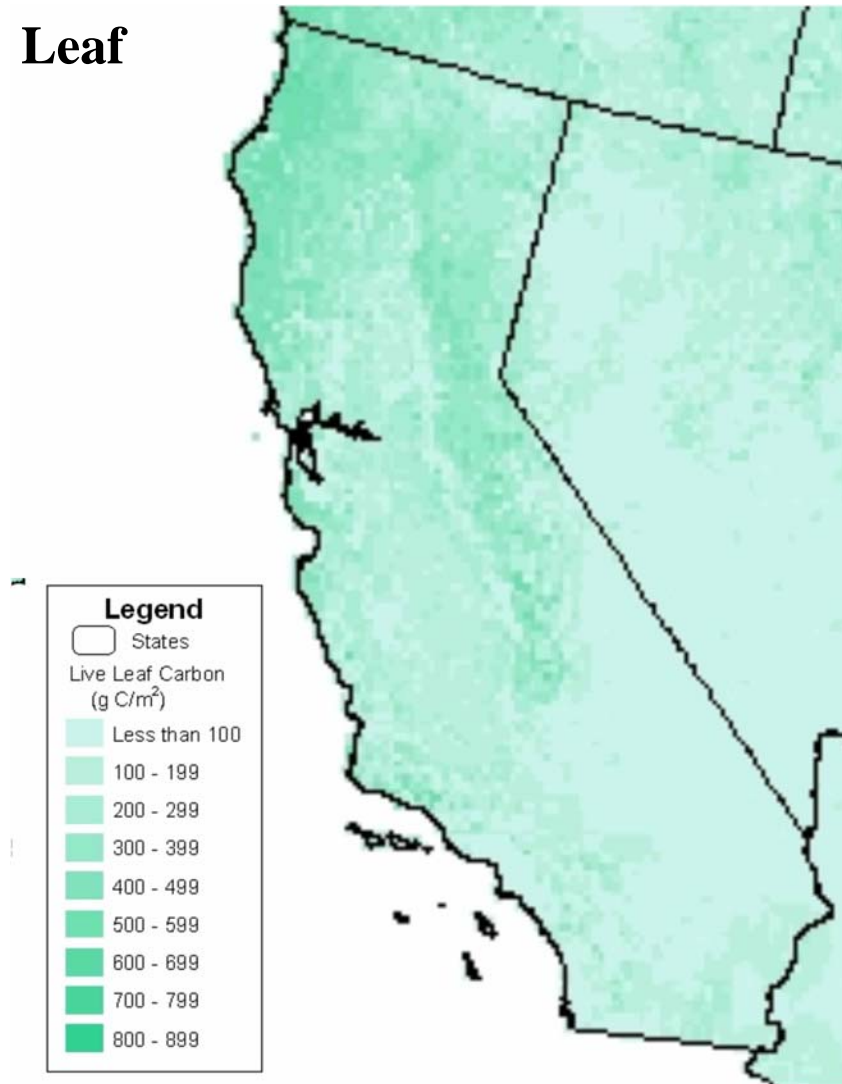

1996 — 0.14 Pg C sink
1997 — 0.39 Pg C sink
1998 — 0.32 Pg C sink

C Source ▬▬▬▬▬ C Sink

-100   -50   0   +50   +100

g C m^{-2} yr^{-1}

Summary:

(a) Since 1982, the terrestrial ecosystem sink for atmospheric CO_2 in North America has been fairly consistent (at ca. 0.3 Pg C per year), except during relatively cool periods.

(b) Regional warming has had the greatest impact on increasing the high latitude (boreal) forest sinks for atmospheric CO_2 in North America.

(c) The continental U.S. has been a consistent ecosystem carbon <u>source</u> of 0.1-0.2 Pg C per year before 1999, led by the western states.
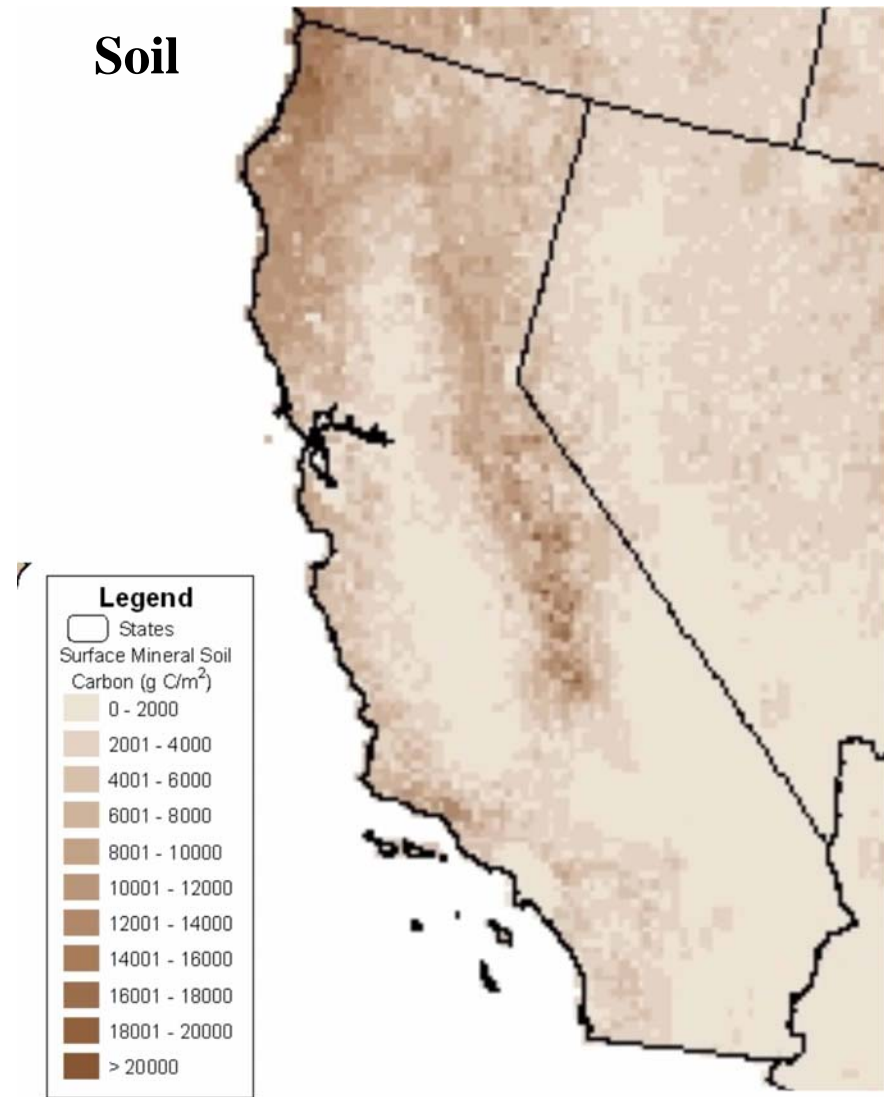
Smoothed Annual Temperature 30° - 60° N. America

Anomaly (2.0, 1.0, 0.0, -1.0, -2.0)

Year (1982–1998)
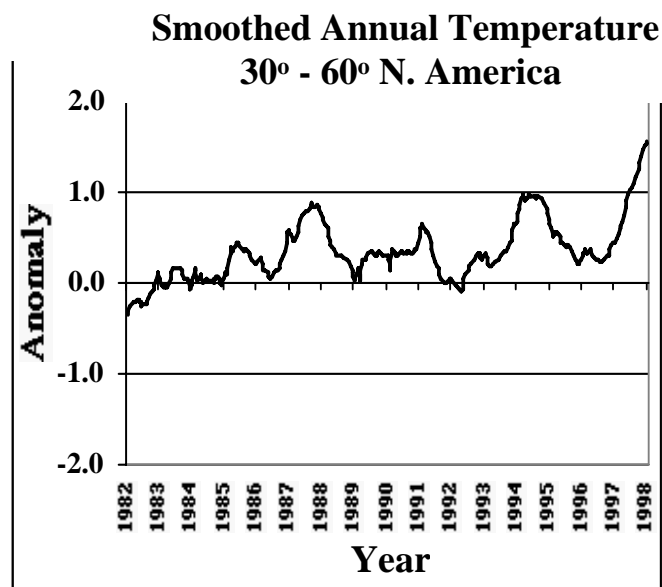
Baseline Carbon Pools for California

Leaf

Soil

Legend

⬜ States

Live Leaf Carbon
(g C/m^2)

- Less than 100
- 100 - 199
- 200 - 299
- 300 - 399
- 400 - 499
- 500 - 599
- 600 - 699
- 700 - 799
- 800 - 899

Legend

⬜ States

Surface Mineral Soil
Carbon (g C/m^2)

- 0 - 2000
- 2001 - 4000
- 4001 - 6000
- 6001 - 8000
- 8001 - 10000
- 10001 - 12000
- 12001 - 14000
- 14001 - 16000
- 16001 - 18000
- 18001 - 20000
- > 20000

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Highest predicted carbon storage is in the **California Coastal Redwood Belt and Siskiyou-Trinity** areas, with average baseline carbon pools in standing biomass (live leaf and wood) in the range of **160-180** t C ha^{-1}. **Sierra Nevada mountains and the Central Coast Range** predicted range is from **50-100** t C ha^{-1}.
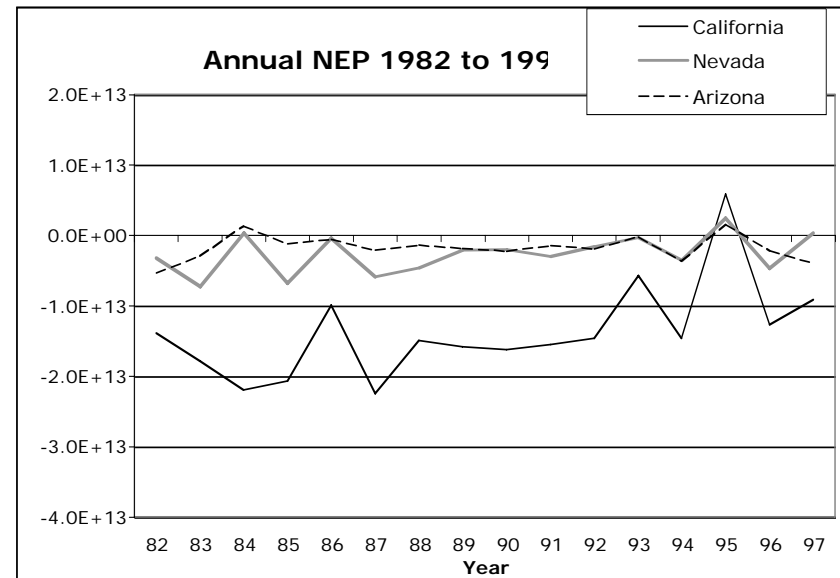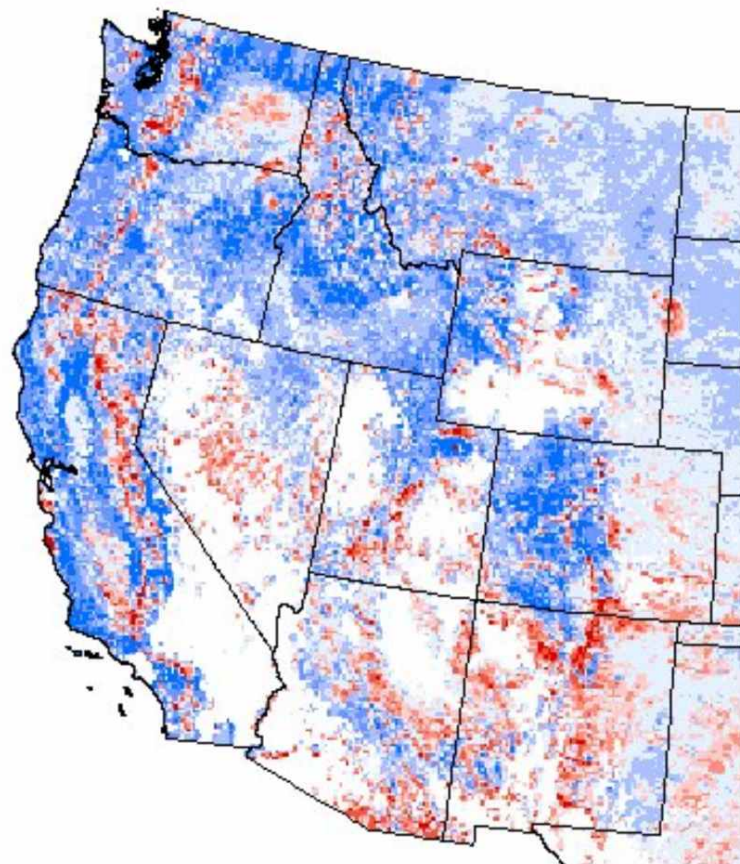
Historical Changes in Baseline Carbon Pools

Net Ecosystem Flux of Carbon,
Summed 1982-1997

g C / m^2

■	66 to 193
■	34 to 65
■	15 to 33
■	.001 to 14
□	0
■	-.001 to -32
■	-33 to -79
■	-80 to -156
■	-157 to -346

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Annual NEP 1982 to 199

— California
— Nevada
- - - Arizona

Annual NEP 1982 to 1

— Idaho
- - - Oregon
- - - Washington
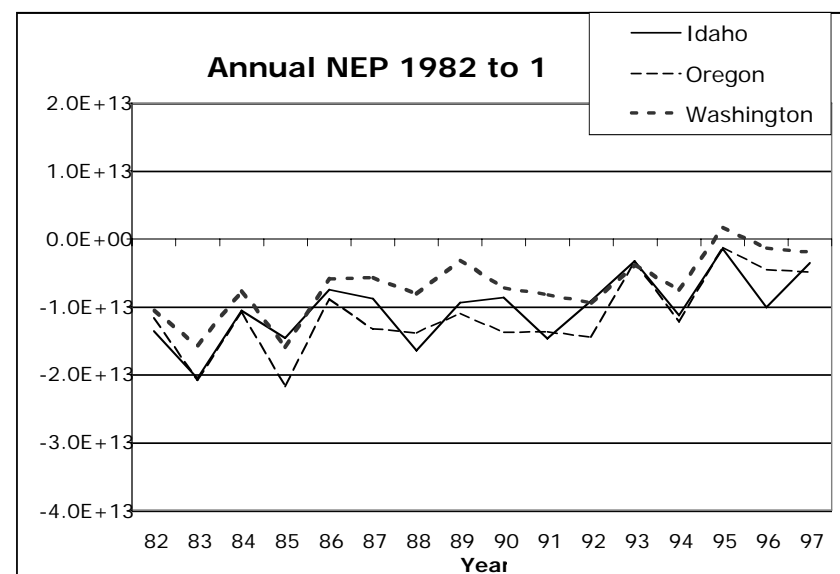
Climate Change Predictions for Carbon Pools: TEMP+

Climate Change Predictions for Carbon Pools: PREC -

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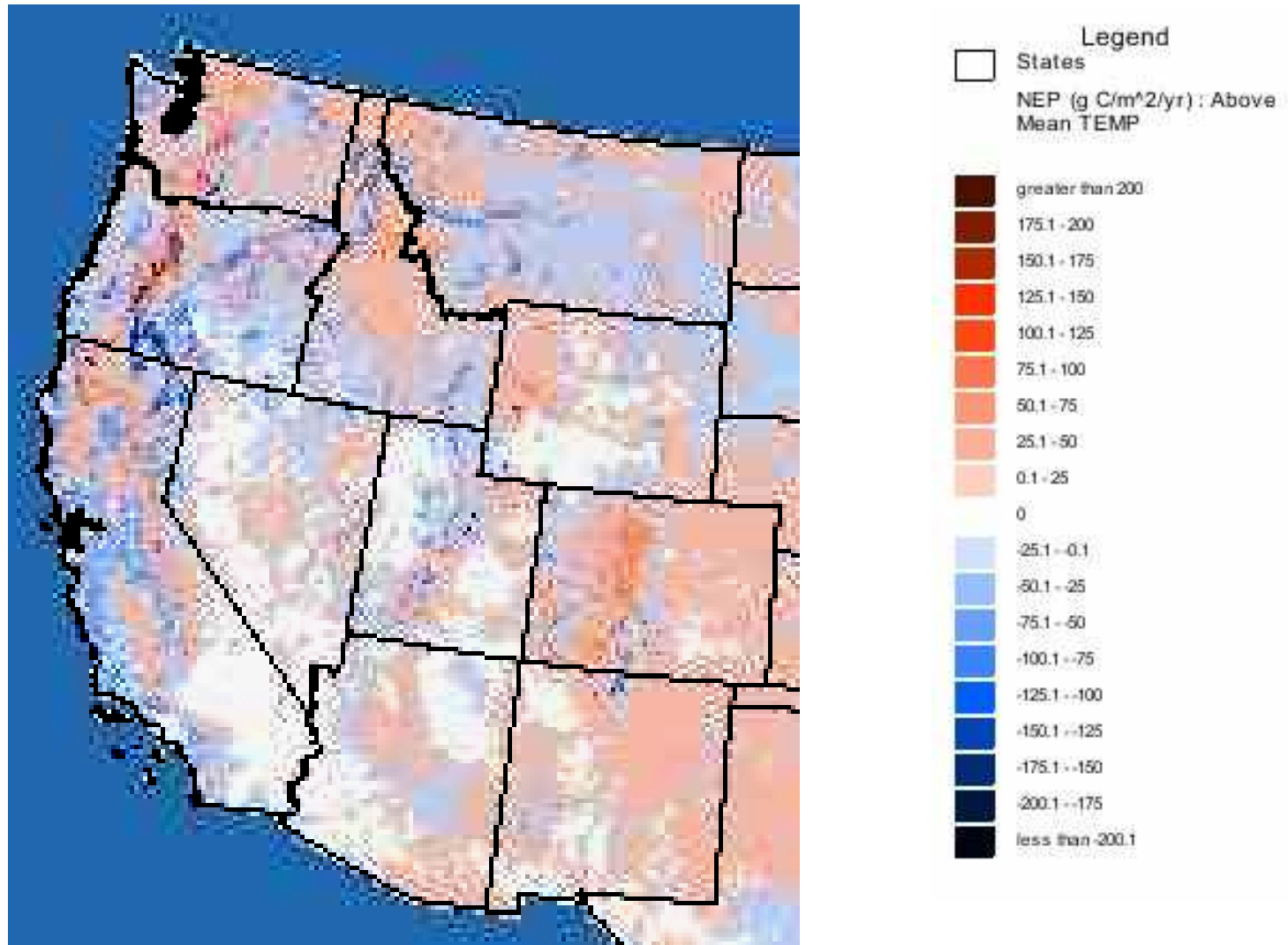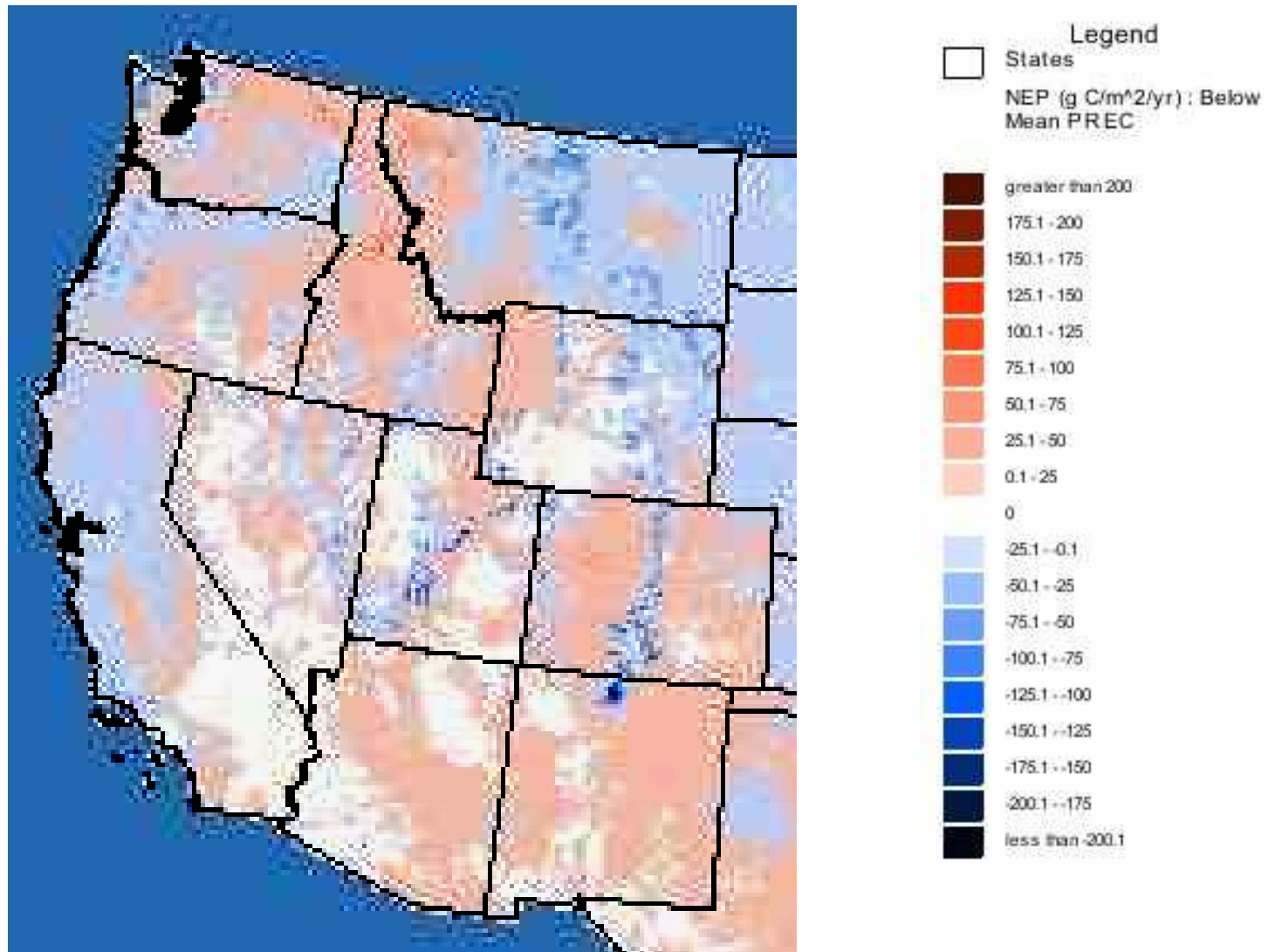
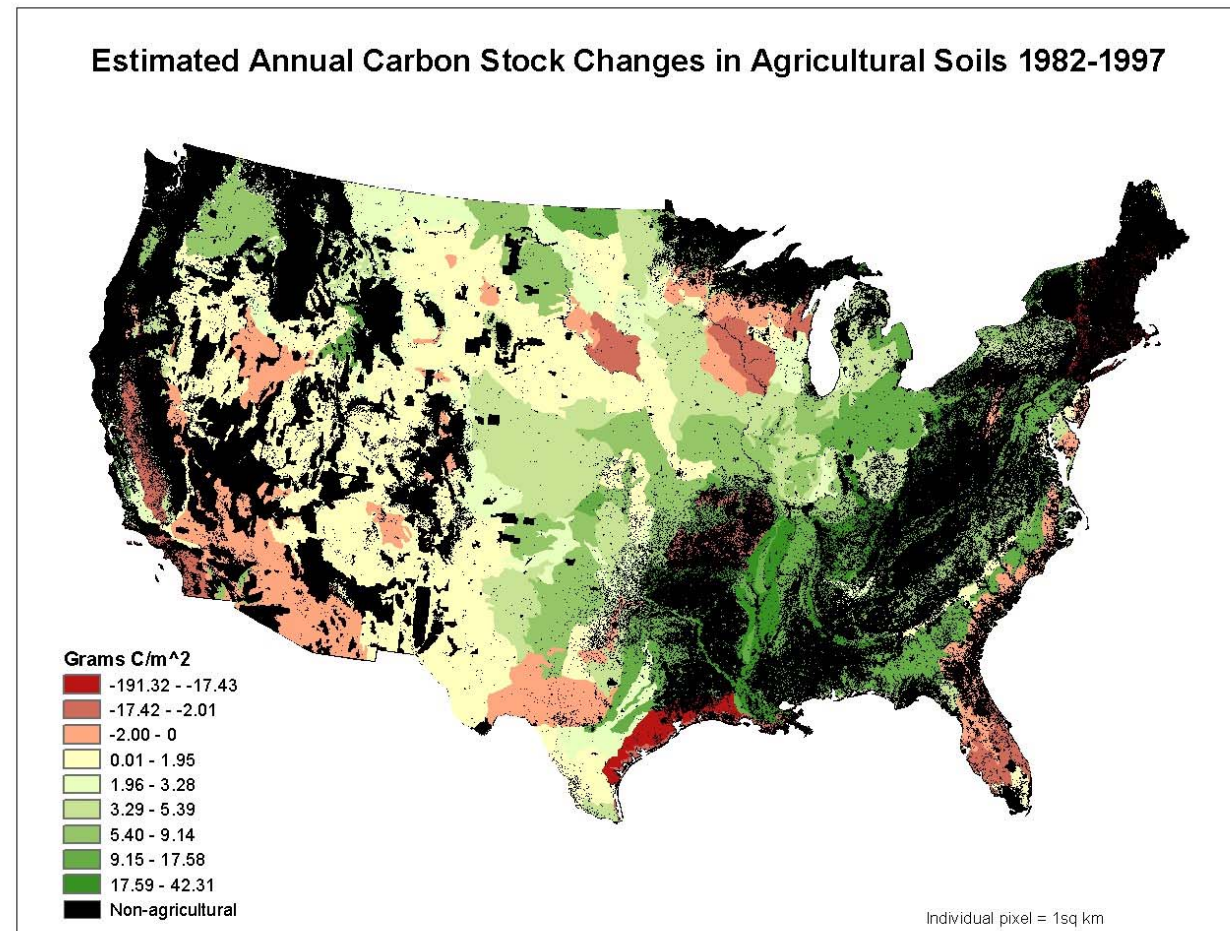# Tracking Land Use Change Impacts on Carbon Pools
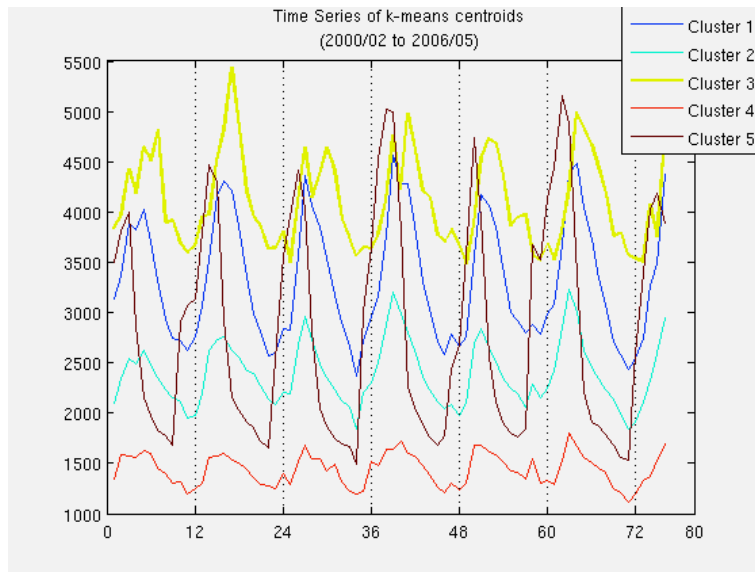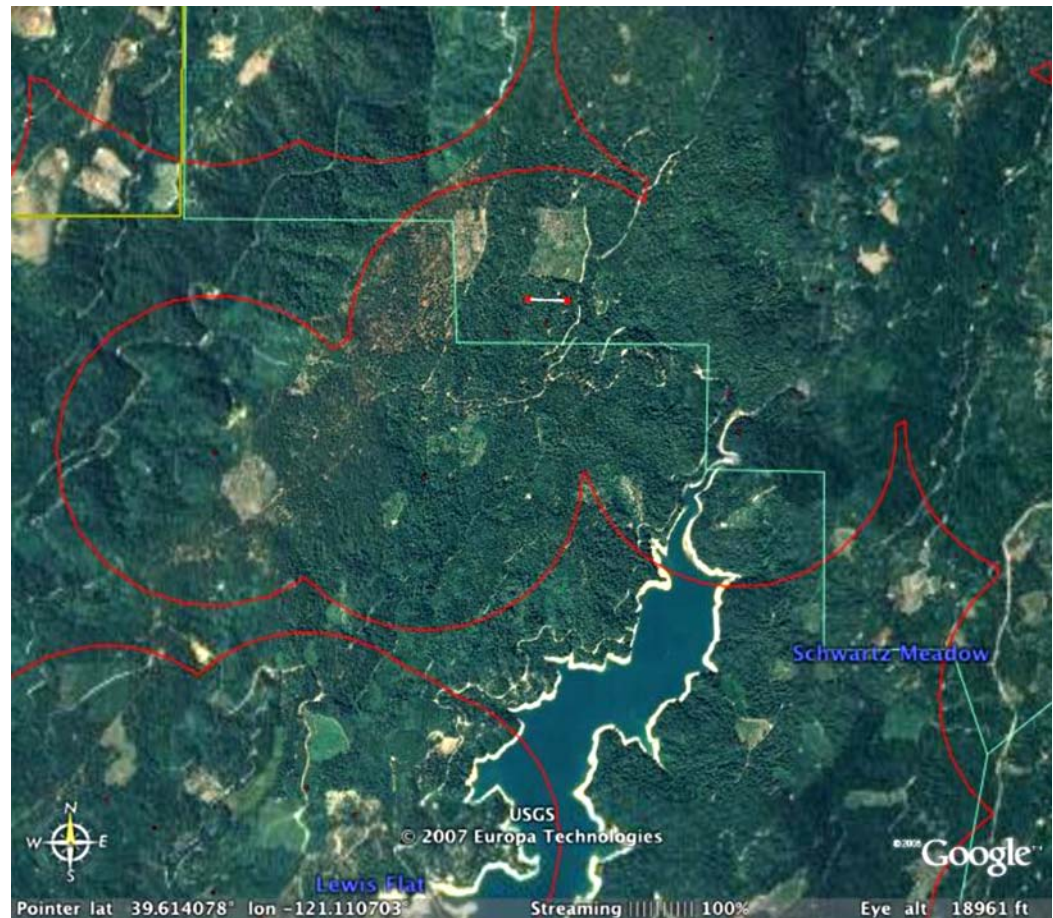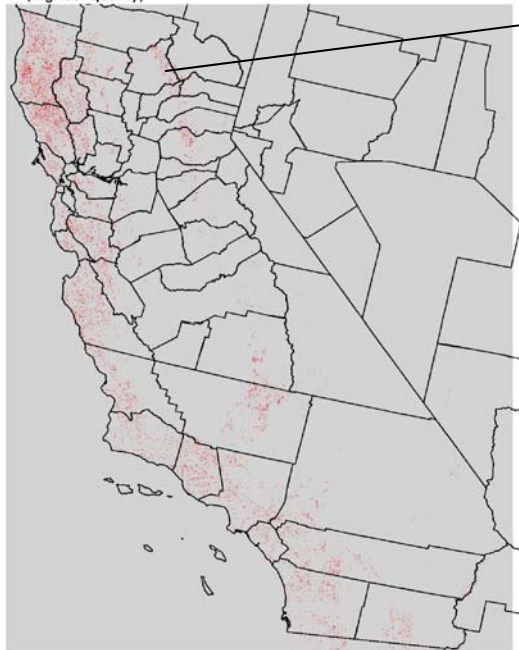
High-resolution satellite image showing cleared patches of land in the Plumas National Forest, California. Red circle lines are 1-km buffer boundaries around the center locations of NASA - MODIS 250-meter areas from which loss of green cover was detected.

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Landsat 30-meter Satellite for Forest Production

CASA Annual NPP circa 2000

Legend

— Roads

Annual NPP

Value

High : 718.754883

Low : -673.038391

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FIA Strata
for
Shasta-
Lassen NF

NPP vs Biomass (9+13)

$y = 8.2058x - 8E+12$

$R^2 = 0.8666$

NPP (lbs C/year)
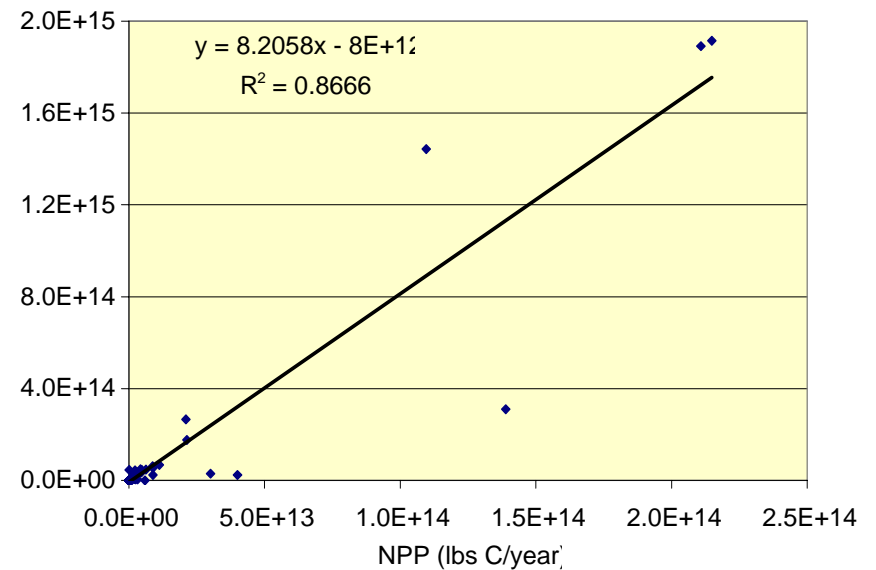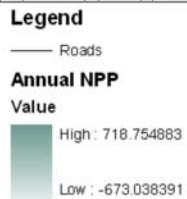
Agricultural Land Use Impacts on Soil Carbon Storage

Estimated Annual Carbon Stock Changes in Agricultural Soils 1982-1997

Grams C/m^2

- -191.32 - -17.43
- -17.42 - -2.01
- -2.00 - 0
- 0.01 - 1.95
- 1.96 - 3.28
- 3.29 - 5.39
- 5.40 - 9.14
- 9.15 - 17.58
- 17.59 - 42.31
- Non-agricultural

Individual pixel = 1sq km

References for the Data Set:

• Eve, M.D., M. Sperow, K. Paustian, and R. Follett. 2002. National-scale estimation of changes in soil carbon stocks on agricultural lands. *Environmental Pollution*, 116: 431-438.
• USDA National Resources Inventory (NRI): http://www.nrcs.usda.gov/technical/NRI/

NASA/USDA Carbon Cycle Science project: *CO$_2$ Fluxes Between Agricultural Lands and the Atmosphere: Towards More Complete Accounting by Integrating Remote Sensing with Simulation Modeling* PI: Stephen Ogle, Colorado State University

http://geo.arc.nasa.gov/sge/casa/cquestwebsite/